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Elliptical Micro-strip Patch Antenna For Circular Polarization Design Using HFSS

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Abstract - *The paper purpose of this paper is to propose a Elliptical micro strip patch antenna design for circular polarization on HFSS. HFSS modeling are developed to calculate the antenna dimensions, for some given resonant frequency, aspect ratio, dielectric constant and height of substrate. The network showed high success rate as the results of HFSS Ansoft simulation.*

***Key Words*: Micro-strip antenna, resonant frequency, Circular Polarization, HFSS simulation**

1.INTRODUCTION

Micro-strip antenna is preferred as compare to other radiators in modern communication systems like cellular phones, personal computer cards for wireless local area network.Micro strip patch antennas have low profile which is conformable to planar and non-planar surfaces, and also have easily fabrication ability using printed circuit board technology. They are also mechanically robust when mounted on rigid surfaces, and compatible with Monolithic microwave integrated circuit (MMIC) designs. When a particular patch shape and excited mode are selected, they are very versatile in terms of resonant frequency, polarization, radiation pattern, and impedance.In this work Elliptical micro strip patch antennas (EMSA) are the ones under consideration as their geometry presents greater potentials for a variety of electrically small low-profile antenna applications. These patch antennas are used for high performance spacecraft, aircraft, missile and satellite applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints. The elliptical shape has been proposed in this design because of several advantages like providing larger flexibility in the design, more degrees of freedom compared to the circular polarization and circular geometry is achieved with single feed. The involvement of Mathieu's and modified Mathieu's function in mathematical analysis geometry makes the least analyzed regular shape geometry of elliptical patch. The involvement of these functions technique traces extremely difficulty in mathematics of elliptical patch geometries. Various methods are available for elliptical patch antenna for the calculation of resonant frequency. These methods obtain resonant frequency for even (*fe*) and odd (*f*o) modes as the function of input variables, which are the height of the dielectric substrate (*h*), dielectric constant (εr), and antenna dimensions (the major axis and the minor axis). But reverse calculation of the antenna dimensions from the inputs like frequencies (*f e, fo*), height (*h)* and dielectric constant (εr) is not available in the literature.

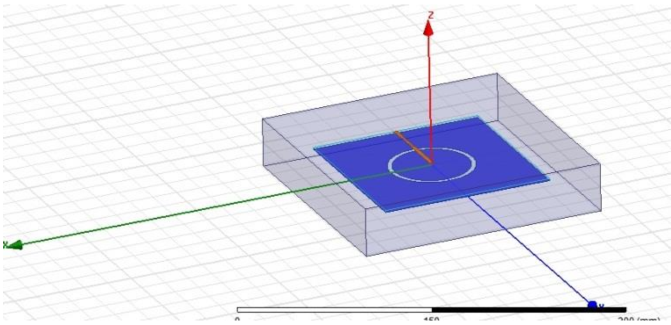

Fig.1 HFSS designed basic model of elliptical micro-strip antenna

2. THEORY OF ELLIPTICAL MICROSTRIP ANTENNA

Elliptical patch antenna is shown in Fig. 1, where *a*isthe semi major axis, *b* is the semi minor axis and a_{eff}isthe effective semi-major axis. The radiated fieldscause two modes that are perpendicular to each other and have equal amplitude, but are 90^{0}out of phase. The feed position is located along the 45º line between the major and minor axis of the elliptical patch. An elliptical patch antenna with optimum dimensions actsas a Circular Polarized wave radiator [2].

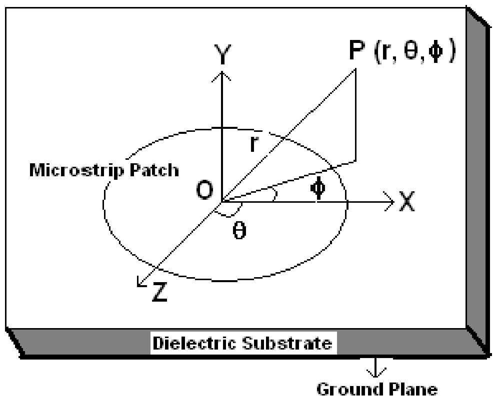

Fig.2 Elliptical Micro strip Patch Antenna for Circular Polarization

Effective Semi Major Axis

$$a_{eff} = a\left[1+\left(\frac{2h}{a\Pi\varepsilon_r}\right)\left\{\ln\left(\frac{a}{2h}\right)+\left(1.41\varepsilon_r+177\right)+\frac{h}{a}\left(0.268\varepsilon_r+1.65\right)\right\}\right]^{1/2} \quad (1)$$

Even Mode Resonance Frequency:

$$f_{11} = \frac{15}{\Pi e a_{eff}}\sqrt{\frac{q_{11}}{\varepsilon_r}} \quad (2)$$

$$q_{11}= -0.0049e+3.788e^2-0.7278e^3+2.314e^4 \quad (3)$$

Odd Mode Resonance Frequency:

$$f_{11} = \frac{15}{\Pi e a_{eff}}\sqrt{\frac{q_{11}}{\varepsilon_r}} \quad (4)$$

$$q_{11}=-0.0063e+3.8613e^2-1.3151e^3+5.2229e^4 \quad (5)$$

Where
a - Semi-major axis
h - Height of dielectric substrate
εr- Permittivity of dielectric substrate
aeff- Effective semi-major axis
e - Eccentricity of elliptical patch
$f_{11}^{e\,o}$- Dual-Resonance frequency
$q_{11}^{e\,o}$- Approximated Mathieu function of thedominant ($TM_{11}^{e\,o}$) mode.

:

3. CIRCULAR POLARIZATION

Polarization is a very important factor in wave propagation between the transmitting and receiver antennas.The polarization plane is the plane containing the electric and magnetic field vectors and it is always perpendicular to the plane of propagation. The contour drawn by the tip of the electric field vector describes the wave polarization. This contour is an ellipse, circle or a line. The polarization direction is assumed in the direction of the main beam unless otherwise stated.

Nowadays circular polarization is very important in the antenna design industry, it eliminates the importance of antenna orientation in the plane perpendicular to the propagation direction, it gives much more flexibility to the angle between transmitting & receiving antennas, also it enhances weather penetration and mobility.

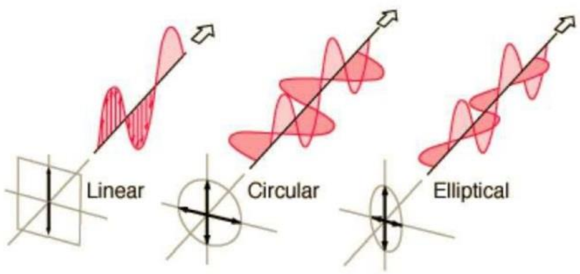

Fig. 3 Types of Polarization

4.CONVENTIONAL ELLIPTICAL PATCHANTENNA

In this study, first a conventional elliptical patch micro-strip antenna, of semi-major and semi-minor axes of length aand*b*, respectively, has been considered. The patch is considered lying in XY planeover a large ground plane with substrate thickness (*h* <<lo), substrate dielectric constant (ε_r) and relative permeability (μ_r= 1) as shown in Fig. (a).

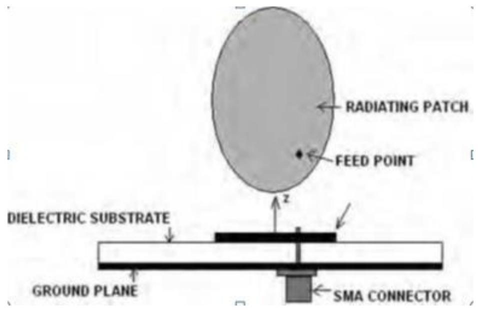

Fig. 4 Geometry and feed arrangement of conventional elliptical patch antenna

The magnetic field in such structure has essentially x and y components. Because *h*<<lo,the fields do not vary along the z-direction and thecomponent of the current normal to the edge of themicro-strip antenna approaches to zero at the edges.With these assumptions, this elliptical structure can be considered as a cylindrical resonator with magnetic sidewalls, bounded at its top and bottom by electricwalls. In the designed structure, length of semi-majorand semi minor axes are a =1.7cm, b = 1.41cm, respectively with eccentricity e = 0.558. The structure has been designed on glass epoxy FR4 substratehaving substrate thickness h = 0.33 cm, substrate relative permittivity ε = 4.5 and loss tangent tan α = 0.0011.

The measured resonancefrequency of this antenna as shown in same figureis 2.261 GHz, which is in close agreement with the simulated frequency. The impedance bandwidthcorresponding to 10 dB return loss is 58 MHz. The following figure shows the resonant frequency curve.

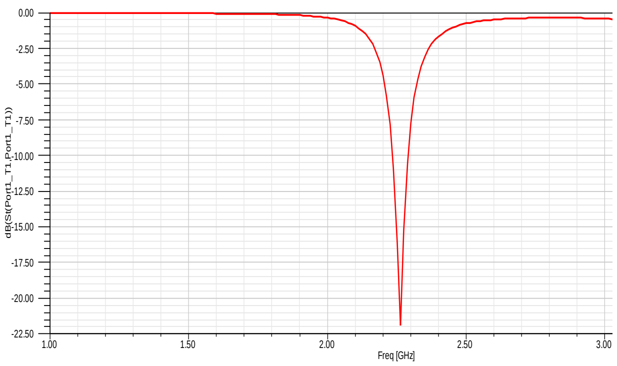

Fig.5 Resonant Frequency curve

TABLE 1

DATAS FROM HFSS

1	2.5	1.92	0.34	2.55	2.799
2	2.6	2.0	0.35	2.55	2.734
3	2.7	2.07	0.36	2.55	2.649
4	2.8	2.15	0.37	2.55	2.548
*5	2.9	2.23	0.38	2.55	2.477
6	2.1	1.5	0.33	3.5	2.757
7	2.2	1.57	0.42	3.5	2.610
8	2.5	1.78	0.45	3.5	2.323
9	2.4	1.71	0.48	3.5	2.397
*10	2.5	1.78	0.37	3.5	2.346
11	2.8	1.86	0.37	4	1.834
12	2.9	1.93	0.41	4	1.723
13	1.8	1.2	0.42	4	2.148
14	1.5	1.0	0.45	4	2.50
15	1.2	0.8	0.48	4	2.985
*16	1.1	0.73	0.5	4	3.199
17	1.7	1.41	0.33	4.5	2.261
18	1.5	1.25	0.35	4.5	2.491
19	2.2	1.83	0.39	4.5	2.610
20	2.5	2.08	0.42	4.5	2.321
*21	2.7	2.25	0.45	4.5	2.109
22	2.5	1.56	0.34	6	2.948
23	2.7	1.68	0.35	6	1.473
24	2.6	1.62	0.36	6	2.842
25	2.2	1.37	0.37	6	3.309
*26	2.1	1.31	0.38	6	3.486
27	2.5	1.47	0.34	10	2.224
28	2.6	1.53	0.35	10	1.046
29	2.4	1.41	0.36	10	2.296

30	2.3	1.35	0.37	10	2.371
*31	2.2	1.29	0.38	10	2.484

5.CONCLUSIONS

The results obtained by using HFSS for elliptical micro-strip patch antennas are in good agreement with available targeted results as compare to results calculated from theoretical approach. Using these HFSS models, various possible dimensions can be obtained to achieve high bandwidth and single feed circular polarization. These models are simple, easy to apply and very useful for antenna engineers to predict both patch dimensions and resonant frequency.

6. References

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